*Revised Detailed Work Plan*

# Traffic Load Monitoring and Projections

*submitted to*

Federal Highway Administration

DTFH61-95-C-00060
Task Order 25

*submitted by*

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*August 11, 1998*

The design of road pavements entails the use of estimates of current and future traffic on each section of road by vehicle class and of the stresses placed on the pavement by these vehicles, usually measured in terms of 18,000-pound equivalent single-axle loads (ESALs). The accuracy of these estimates depends on:

- the amount and accuracy of traffic and ESALs-per-vehicle data collected;
- the quality of forecasts of rates of growth in truck traffic; and
- the procedures for using this information to estimate the cumulative ESALs to which the pavement will be subjected.

Budgetary trade-offs exist between the amount of data to be collected and the cost-effectiveness of the resulting pavement design. The principal focus of this Task Order is on analyzing the benefits and costs of using project-specific traffic data and forecasts rather than average data for forecasting cumulative ESALs.

The first section below provides some background on procedures that can be used for estimating annual average daily traffic (AADT) by vehicle class (VC), a key component of ESALs estimation. The second (and lengthiest) section presents our expanded Work Plan for performing this study. Finally, Section 3 presents our planned schedule for the study, planned person-hours by task, and planned expenditures by task. We do not anticipate any problems in performing this study beyond the analytic challenges discussed in Task C of our Work Plan.

# 1. Estimating AADT by VC

There are several different procedures that can be used for estimating AADT by VC. Some of the more significant of these procedures are discussed below:

1. *Volume Factors.* A common procedure is to obtain short-duration classification counts (most typically, for a 48-hour period on weekdays) and to adjust these counts for seasonal and day-of-week variation in traffic volumes by using the same factors as are applied to volume counts. In this procedure, for any site, a set of classification counts is obtained, and the *same* factor is applied to each of these counts. Since the same factor is applied to each count, for any pair of classes, the ratio between their estimated AADTs is the same as the ratio between their original counts. Similarly, the ratio of truck AADT to total AADT is the same as the ratio of the original count of trucks to the original count of total vehicles. This procedure effectively assumes that a short-duration classification count provides an adequate indication of how total traffic is distributed among vehicle classes.

   The principal problem with this procedure is that, at most sites, truck traffic drops appreciably on weekends and automobile traffic does not. Hence, the use of weekday classification counts in this procedure produces a significant upward bias in the resulting estimates of truck AADT.[1]

2. *Factoring by Class.* A common variant of the above procedures that produces appreciably better results uses separate sets of factors for each of several sets of vehicle classes. This procedure factors truck counts with seasonal and day-of-week factors that are obtained entirely from data for trucks. Hence, the factoring adjusts the raw truck counts for the decline in traffic volume that generally occurs on weekends, avoiding the upward bias produced by the preceding procedure.[2]

3. *Distributions from Continuous Classification Sites.* A third procedure is to use estimates of AADT by VC obtained at one or more continuous classification sites (CCSs) to obtain distributions of AADT across VCs, and to apply these distributions to estimates of total AADT obtained at other sites. This is a particularly good procedure for estimating AADT by VC at sites that are reasonably close to a CCS on the same road. This procedure is used on the Interstate System (IS) by the Virginia Department of Transportation (DOT).[3]

4. *Using Factors by Class from Nearby CCSs*. In the case of sites that are reasonably close to a CCS on the same road, another alternative is to use seasonal and day-of-week factors for trucks from the CCS to adjust short-duration classification counts obtained at these sites. (This procedure differs from Procedure 2 in that the factors are obtained from a single nearby CCS on the same road, and it differs from Procedure 3 in that the short-duration counts are classification counts rather than volume counts). This procedure generally will produce somewhat better estimates than Procedure 3.

5. *Seven-Day Classification Counts.* The best way of minimizing errors introduced by day-of-week variations is to perform all classification counting for seven-day periods.[4] Seven-day classification counts may be used in unfactored form, or they may be adjusted using seasonal factors obtained for sets of vehicle classes that distinguish (at least) two-axle vehicles from trucks with three or more axles. A more costly option, recommended by Hallenbeck[5], is to obtain seven-day classification counts at three or four-month intervals and to average the results without factoring.

Currently, most states use one of the first two procedures. In order to limit the extent of our effort, we plan on focusing on these two procedures and on

[1] Herbert Weinblatt, "Using Seasonal and Day-of-Week Factoring to Improve Estimates of Truck Vehicle-Miles Traveled," *Transportation Research Record 1522*, 1996.

[2] Ibid.

[3] Cambridge Systematics, *Virginia State Traffic Monitoring Standards*, Virginia Department of Transportation, June 1995.

[4] Mark Hallenbeck, *Results of the Empirical Analysis of Alternative Data Collection Sampling Plans for Estimating Annual Vehicle Loads at LTPP Sites,* prepared by WS TRAC for FHWA, 1996.

[5] Ibid.

identifying the advantages of the second procedure. An alternative, which we believe goes beyond the scope of the original Statement of Work, would be to add analyses of the fifth procedure. However, adopting this alternative would require us to reduce the attention paid to some other issues (e.g., lane distribution factors or growth rates).

## 2. Task Plan

Our proposed analyses are designed to estimate: the effects of variations in traffic characteristics on the pavement design thicknesses indicated by the current AASHTO procedure[6]; and the effects on expected life-cycle pavement costs of using site-specific vs. average values for various traffic variables. The latter estimates will reflect the effects of uncertainty in both the actual values of the traffic variables used and in pavement performance. In addition, we will develop guidelines for State highway agencies (SHAs) wishing to perform similar analyses, and we will provide FHWA with copies of any of our computer programs which may be of value to SHAs for performing these analyses.

We observe that, even when average values are used by SHAs, separate averages usually are obtained for each functional system (or at least for the higher functional systems). Accordingly, all our analyses will be performed for a single functional system. As requested by several reviewers, we will use the rural other principal arterial (OPA) system. The rural OPA system appears to present a significant challenge to pavement design. It combines relatively high truck volumes with substantial regional variability in truck volume patterns and load characteristics. The use of relatively modest levels of reliability in pavement designs for this system[7] also makes rural OPA pavements somewhat more prone to premature failure than systems for which higher reliability levels are used. Also, we will further limit our analyses to four-lane roads (which are more interesting than two-lane roads because they require the use of lane distribution factors).

The proposed effort is divided into eight tasks, each of which is discussed below.

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[6] The evaluation of the effects of expected changes to the AASHTO procedure is outside the scope of this project.

[7] The "AASHTO Pavement Guide" (American Association of State Highway and Transportation Officials, *AASHTO Guide for Design of Pavement Structures*, 1993, Table 2.2, page II-9) suggests a 75-95 percent reliability level for ROPA pavements (and also for rural major collectors), but higher ranges are suggested for rural Interstates and for all urban functional classes except for local streets. (A pavement reliability level of 75 percent implies a 75 percent probability that the pavement will outlast its design life.)

### *Task A – Prepare Detailed Work Plan*

The first task of the proposed effort consists of reviewing the Task Plan contained in our May 8 Proposal and making appropriate changes to it. These changes reflect comments received from the COTR and other reviewers about the plan and our proposed analyses, as well as additional thought on our part about the best way to achieve the study's goals. The current Detailed Work Plan represents the final version of the product of Task A. This plans includes: a bar chart showing the planned schedule for the study; a table showing planned person-hours by person and task; and a chart showing estimated expenditures by task.

After receipt of comments by the COTR and other reviewers on this draft Work Plan, the plan will be revised in accordance with these comments. The revised Work Plan will be submitted within seven days of receipt of comments.

### *Task B – Review Literature and Set Up Analysis*

We propose expanding Task B so that it consists of two subtasks: The literature review requested in FHWA's original Delineation of Contractor Tasks; and some initial steps required by the Task C sensitivity analysis. We propose performing these initial steps as part of Task B so that FHWA will have an opportunity to review and comment upon the results of these steps before we begin the major analyses to be performed in Task C. The two proposed subtasks are discussed below.

### Task B1 – Literature Review

Subtask B1 consists of a review of literature related to the issues to be studied. Areas to be covered in this literature review will include:

- The methodologies currently used for estimating traffic-related variables used by the AASHTO design equations and forecasting the future values of these variables;
- The range of values observed for these variables on ROPA system, the most typical values observed, and factors affecting variations in these values;
- Typical values for material properties and pavement structural characteristics;
- Typical values used for the standard errors (or variances) of design period traffic prediction and pavement performance prediction;
- Typical values used for the reliability level and the reliability design factor ($F_R$);
- Typical costs per mile for pavement construction / reconstruction and pavement overlays on ROPAs, by pavement type, pavement thickness, number of lanes, and other design characteristics; and

- Typical highway-user costs resulting from traffic disruption due to pavement reconstruction and resurfacing, as a function of AADT.

The literature review will include the use of transportation-related information systems (such as the Transportation Research Information System) to identify recent literature in the above areas, a review of several related studies produced by the Long Term Pavement Performance Program, and telephone contacts with Transport Canada and the Netherlands consulate and/or the Netherlands highway agency to obtain relevant information about the Canadian and Netherlands Strategic Highway Research Programs.

Documents identified in the course of this task will be obtained, as appropriate, and reviewed for relevance to the study. Finally, a report will be prepared presenting our findings in each of the above areas along with an expanded list of relevant documents. This report will be submitted to FHWA within two months of the start of the contract.

### Subtask B2 – Set Up Sensitivity Analysis

There are two preliminary steps required by the Task C sensitivity analysis that we propose to perform as part of Task B instead of at the start of Task C.

One step consists of adopting an operational definition of a normal pavement life cycle to be used in the analyses of Task C and subsequent tasks. Our current plan is to define a normal pavement life cycle as consisting of construction (or reconstruction), followed by two overlays, followed by pavement reconstruction, with resurfacing or pavement reconstruction occurring when PSR declines to 2.5. The design lives of pavement reconstruction and overlays will be chosen so that they add to a specified length of time (e.g., 40 years).

The second preliminary step consists of specifying appropriate values of several variables to be used in our analyses: a) for describing a "typical" high-volume road to be analyzed; and b) for describing various alternatives to be analyzed. The requirement for this step is best understood after reading our proposed plan for Subtask C1 (below), which includes discussions of these variables and of a preliminary set of alternatives to be analyzed. As observed in that discussion, values for these variables (both for a typical road and for the various alternatives) are best specified after completion of the literature review. However, as in the case of selecting an operational definition of pavement life cycle, we believe that it is preferable that proposed values for these variables be specified prior to FHWA's decision as to whether or not we should proceed to Task C.

We will submit a brief Task B2 Report presenting the results of these steps within 2.5 months of the start of the contract.

## *Task C – Sensitivity Analysis*

We have broken the sensitivity analyses into two subtasks: analyses of sensitivity to errors in individual variables (Subtask C1); and analyses of sensitivity to combinations of these errors (Subtask C2). The first group of analyses is necessary in order to perform those in the second group, and it also will produce results that are interesting in themselves. In particular, it will provide information about the relative sensitivity of ESALs forecasts to several different types of error, and thus the relative importance of reducing the different types of error. Most or all of these analyses will be performed using PC SAS.

### Subtask C1 – Individual Variables

In Subtask C1 we will perform analyses of the effects of individual variables on accumulated ESALs, pavement design, pavement life, and life-cycle costs. The RFP is ambiguous as to whether the analyses should be performed for both asphalt concrete (AC) and Portland cement concrete (PCC) pavements or only for PCC pavements. To avoid potential controversies about the cost-effectiveness of the two types of pavement, we will limit our Task C analyses to PCC pavements with AC overlays, but we will consider introducing AC pavements in Task D. We do not plan to analyze the variation in results (which are likely to be minor) that may occur for the three types of PCC pavement (JPCP, JRCP and CRCP); instead we plan to perform all Task C analyses using jointed plain concrete pavement (JPCP). As stated above, costs will be estimated over a full life cycle of the pavement, most likely consisting of pavement construction/reconstruction, two overlays, and reconstruction.

We will begin the sensitivity analysis (in Subtask B2) by choosing typical values for rural OPAs for each of the following variables:

- AADT;
- Percentages of vehicles in each vehicle class;
- Lane factors;
- Growth rates;
- Average ESALs per vehicle for each vehicle class;
- Discount rate;
- Agency and user costs of pavement reconstruction and resurfacing;
- Level of reliability; and
- The various pavement performance variables (material properties and pavement structural characteristics).

We will use the AASHTO pavement-design and pavement-wear equations to estimate the life-cycle costs of correctly designing the pavement of a road with the above characteristics. All costs will be discounted to the initial year of the life cycle using a discount rate of seven percent.[8] We may also repeat the analyses with a lower discount rate (such as five percent), as advocated by some economists, to reduce the extent to which out-year expenditures are discounted.

In the above step, and in all subsequent applications of the AASHTO design procedures, we will make one modification in the procedure: we will use PCC slab thicknesses and AC overlay thicknesses that are determined by the AASHTO procedures *without rounding* (e.g., if the last step of the procedure for determining AC overlay thickness produces a value of 3.91 inches, we will assume an overlay of 3.91 inches rather than the more likely overlay of 4.0 inches). This modification to the procedure is necessary in order to exclude from our results the random effects of rounding on life-cycle costs.

We have designed our analyses to focus on individual *sources* of error rather than overall error, and we propose to eliminate from our analyses some sources of error that we believe to be of only limited interest in order to devote more resources to sources that we believe to be of greater interest. Thus, we have not proposed to analyze the effects of error produced by automatic vehicle classifiers. In the case of two-axle vehicles, these errors can be quite large.[9] However, proper classification of two-axle vehicles has a fairly insignificant effect on total ESALs; and classification errors for heavier vehicles are much smaller.

We will start with some simple analyses of the effects of random variation in short-duration vehicle counts. We will first estimate the life-cycle pavement costs for a road with the above typical characteristics under the assumption that we have correctly forecasted life-cycle ESALs. We will then estimate these costs twice more under the assumption that our forecast of life-cycle ESALs has decreased (or increased) as a result of random variation in the short-duration vehicle counts.[10] For this simple analysis, we will assume a uniform decrease (or increase) in 48-hour heavy-vehicle counts that is reasonably representative of an error of either two or three standard deviations. Finally, we will repeat our analysis two more times, assuming a corresponding uniform decrease (or increase) in seven-day heavy-vehicle counts.

The last pair of analyses will reflect the effects of appreciably lower percentage errors in the counts (due to the larger number of vehicles counted in the longer

[8] The Office of Management and Budget (OMB) currently requires that a seven percent discount rate be used as one alternative in any benefit/cost analysis of capital expenditures.

[9] Indeed, most classifiers undercount two-axle six-tire trucks (FHWA Class 5) by more than 50 percent, and some undercount these trucks by more than 80 percent. (Bruce A. Harvey et .al., *Accuracy of Traffic Monitoring Equipment*, prepared by Georgia Tech Research Institute for the Georgia Department of Transportation and FHWA, June 1995, Tables 4, 7, 14, 17, 21, 24, 27, 30, 32, 35 and 38.)

[10] This example can also clarify the earlier discussion of the need not to round the design thicknesses indicated by the AASHTO equation. We wish to estimate the effects of under-estimating forecast ESALS. But rounding the design thickness up (from 3.91 inches to 4.0 inches) would mitigate (or even reverse) these effects, thus distorting the results of our analysis. (Similarly, rounding down would exaggerate these effects.) For this reason, we perform our analyses without rounding.

time period). A comparison of the five estimates of life-cycle costs will provide an indication of the effect of random variation in short-duration counts on life-cycle pavement costs and the extent to which this effect can be reduced by extending the length of the counting period. (However, this preliminary analysis will *not* address a potentially more significant benefit of seven-day counts: eliminating the effect of errors in the day-of-the-week factoring process.)

Following this first set of analyses, we will perform several sets of similar analyses addressing other sources of error in the ESALs-forecasting process. Table 1 provides a list of the analyses that we currently plan to perform. However, this list is still evolving, and it may also be reduced somewhat to keep our Task C effort within budget. In the course of these analyses, we plan to address the effects on life-cycle pavement costs of:

- Typical factoring errors in the factoring by class procedure for estimating AADT by VC (Procedure 2 in Section 1, and Part A of Table 1);

## Table 1. Potential Alternatives to be Analyzed

A. Seasonal and Day-of-Week Factors for Combination Trucks:

1. A typical AADT/weekday-count ratio for a typical state.
2. A typical AADT/weekday-count ratio for a road with relatively high weekend truck volumes.
3. A typical ratio of AADT to harvest-season weekday counts.
4. A typical ratio of AADT to harvest-season weekday counts for a road with little or no harvest-season traffic.
5. The ratio of AADT to peak-season weekday counts for a road with atypical seasonal peaking.

B. Percentages of Trucks Factors:

1. Typical percentages for a typical state, obtained from a 365-day AVC count.
2. Percentages obtained at this site using a 48-hour weekday AVC count.

C. Truck Lane Distribution Factors:

1. Typical lane distribution factors.
2. High lane distribution factors.
3. Low lane distribution factors (trucks uniformly distributed across lanes).

D. Growth Rates:

1. Typical exponential growth rates for heavy trucks and for other vehicles.
2. A single typical exponential growth rate for all traffic.
3. Growth rates for heavy trucks and other vehicles that decline over time.
4. Exponential growth rates for heavy trucks and other vehicles in a high-growth area.
5. A single exponential growth rate for all traffic in such an area (evaluated relative to D4).
6. Exponential growth rates for heavy trucks and other vehicles in a low-growth area.
7. A single exponential growth rate for all traffic in such an area (evaluated relative to D6).

E. ESAL Factors by Vehicle Type:

1. Annual average values for typical road.
2. Values for road for which values are at high end of range.
3. Values for road for which values are at low end of range.
4. Values obtained for typical road when values tend to be seasonally high.
5. Values obtained for typical road when values tend to be seasonally low.
6. For road for which values vary by direction, values by direction.

- The upward bias that results from using volume factors (Procedure 1 in Section 1, and Part B of Table 1);

- Inappropriate lane-distribution factors (C in Table 1);

- Inappropriate growth rates (D); and

- Inappropriate ESAL factors (E).

An important step in performing our analyses will entail developing operational definitions for each of the alternatives to be analyzed. In most or all cases, these definitions will be drawn from the literature reviewed in Task B;[11] however, it is possible that it will be necessary to develop some of the definitions on the basis of informed judgment. Although development of operational definitions is logically a part of Task C, we suggest that these definitions be developed in the first phase of our study so that they may be reviewed by the COTR prior to initiation of Task C. Accordingly, as indicated in our discussion of Task B, we suggest that these definitions be developed in a new subtask, Subtask B2.

The principal product of Subtask C1 will be two sets of results. One set will present the effects on life-cycle costs of each of the potential sources of error analyzed These effects will be presented: in terms of the magnitude of the increase or decrease in the discounted present value of costs per mile per year after allowing for the residual value at the end of the analysis period; and also in terms of the percentage increase or decrease in the discounted present value of these costs. The second set of results will display the effects that each of the variables considered has on the pavement design thickness indicated by the AASHTO procedure. A report presenting these results and documenting the procedures and data used will be submitted to FHWA within 45 days after receipt of a notice to proceed on Task C.

### Subtask C2 – Combined Effects

The results of the Subtask C1 analyses will be used as the basis for more comprehensive analyses of the effects on life-cycle costs of three or more approaches to developing forecasts of design-life ESALs. These will include one very simple approach, at least two relatively sophisticated approaches, and possibly an intermediate approach. These analyses will provide estimates of the differences in the expected life-cycle pavement costs produced using the alternative approaches and, in particular, the estimated cost reductions achievable if the more sophisticated approaches are used instead of the simpler approaches.

[11] For example, the truck percentages used in the Group A and B alternatives (in Table 1) are likely to be based (at least in part) on data from Mark Hallenbeck, *Vehicle Volume Distributions by Classification*, prepared for FHWA by Chaparral Systems Corporation and Washington State Transportation Center, 1997.

The simple approach will make maximum use of average values in developing the ESALs forecasts. In particular, this approach will use:

- Volume factors for estimating AADT by VC;
- A single statewide-average growth rate for all traffic;
- A small number of statewide-average ESAL factors (perhaps distinguishing only four-tire vehicles, buses and single-unit trucks, single-trailer trucks, and multi-trailer trucks); and
- (Perhaps) uniform lane-distribution factors.

The more sophisticated approaches will use procedures that are consistent with those recommended by the updated Traffic Monitoring Guide, now being developed by Mark Hallenbeck. It is likely that these approaches will use:

- Separate seasonal/day-of-week factors for each of several sets of VCs, possibly varying by substate region;
- Separate growth rates for at least two sets of VCs (e.g., heavy trucks and other vehicles);
- Separate ESAL factors for 13 VCs and/or a smaller number of ESAL factors derived using road (and possibly direction) specific data; and
- Recommended lane-distribution factors.

We will assume that a road with the typical characteristics adopted in Subtask C1 is analyzed using each of the approaches to be studied. Initially, we will assume values for all variables used by each approach that are internally consistent and also are appropriately consistent with the values used by the other approaches. Also, we will initially adjust these values so that the more sophisticated approaches produce accurate forecasts of life-cycle ESALs for the road in question and the simple approaches produce forecasts that reflect the effects of any inherent biases that they incorporate (such as underestimating growth in truck traffic due to the use of a single growth rate for all traffic).

For each of the variables in question, we will treat the values selected above as means of appropriate distributions. Separate distributions will be used for:

a) The vehicle counts obtained for each VC;

b) Each of the seasonal/day-of-week factors obtained from continuous classification sites;

c) The actual degree of seasonal and day-of-week variation in traffic on the road in question for each VC;

d) The actual rate of growth of traffic in each set of VCs on the road in question;

e) The actual lane distribution of truck traffic;

f) Each of the ESAL factors used; and

g) Actual average ESALs per vehicle, by VC or set of VCs, for the road in question.

One additional distribution will be used to represent differences between presumed and actual pavement wear conditions due to factors (such as soil condition and properties of the materials used) that are not related to traffic on the road.

Each distribution used will be judgmentally selected to be reasonably consistent with relevant information obtained in the course of our literature review.

Next we will run a large series of Monte Carlo trials.[12] Each trial will use a separate set of random numbers to obtain a value for each variable of interest from the appropriate distribution. For each trial, this set of values will then be used to obtain estimates of actual life-cycle costs for using pavement designed by applying the AASHTO pavement-design procedure to forecasts of cumulative ESALs obtained using each of the procedures under consideration. In this step, the above values will be used in two different ways.

The sets of distributions labeled (a), (b) and (f) represent errors in the data that are used to forecast ESALs on the road in question. These errors may result in either underestimating or overestimating life-cycle ESALs, and hence in either underdesigning or overdesigning the pavement. For each trial and each ESALs forecasting procedure, the resulting effect on life-cycle costs will be estimated; and the size of this effect, in both absolute and percentage terms, will be recorded.

The remaining sets of distributions represent ways in which the characteristics of the road in question may differ from those of the typical road assumed at the start of this subtask. As a result of these differences, life-cycle ESALs on the road in question will differ from those used in the pavement-design procedures. Consider the case in which the difference produces actual life-cycle ESALs that are lower than those used in the pavement design. The pavement design will be unchanged and its initial costs will not rise; but it will last longer, and so its life-cycle costs will decline. However, in theory, this decline will not be as great as would occur if the pavement design were modified to reflect the lower value of life-cycle ESALs. In this case, we are more interested in this latter comparison (the increased cost due to imperfect knowledge) than in the former comparison (the cost saving due to life-cycle ESALs being lower than expected). Hence, it is the latter comparison that we will use in our statistics; and we will handle similarly

[12] Minnesota DOT has offered us the use of a mainframe SAS program (which can be easily adapted for PC use) that is designed to perform Monte Carlo simulations similar to those we plan to perform. If this program can be readily adapted for performing a significant portion of our proposed analyses, it will enable us to expand the number of ESALs estimation/forecasting approaches analyzed.

the case in which actual life-cycle ESALs are higher than those used in the pavement design.

For each ESALs estimation/forecasting procedure analyzed, these simulations will produce estimates of the mean value of life-cycle pavement costs, mean values of the absolute and percentage differences between these costs and those obtained using perfect forecasts of ESALs, and the distributions of these values around the means. The Task C2 Report will present tabular comparisons of these means and graphical displays of the corresponding distributions. In addition, the report will describe the ESALs-estimation procedures analyzed and it will document the conduct of the analyses. Significant differences between the effectiveness of the procedures analyzed will be observed and discussed. However, because of the use of judgmental distributions, more modest differences in effectiveness will be identified as only suggesting the relative superiority of one of the procedures rather than demonstrating such superiority.

The Task C2 Report will be submitted within three months of receipt of a notice to proceed with Task C.

### *Task D – Case Studies*

The Statement of Work requests the conduct of case studies in calculating ESALs to determine the benefits and costs of adopting improved methodologies. These case studies will enable us to evaluate these benefits and costs for a sample of states. They also will be useful in refining the benefit/cost evaluation procedures and in developing guidelines for the use of these procedures by states, as requested in Task E.

Five states will be selected for case studies. These states will be selected for diversity in the methodologies they use for collecting and using data on traffic by vehicle class and on ESALs per vehicle. The selection will be made in consultation with the COTR and other FHWA personnel familiar with state traffic data collection programs. A memorandum proposing the states to be selected and the reasons for their selection will be submitted to the COTR for approval.

Following approval of the five states, copies of all completed task reports will be sent to each of the five states (to provide an understanding of the goals of our study), and visits to these states will be arranged for the Principal Investigator (Dr. Weinblatt) and the civil engineer (Dr. Alfelor). During these visits, we will meet with senior staff currently working in the areas of pavement management, pavement design, planning and corridor analysis, traffic data collection, and traffic forecasting. A review will be conducted of: the procedures currently being used by these states for estimating and forecasting truck traffic and cumulative ESALs on individual highway sections; current costs of obtaining and analyzing the underlying data; the procedures for using these estimates in pavement design, pavement management, and highway planning; and the estimated costs of obtaining better site-specific data.

For each state we shall adapt our Task C procedures to analyze the effects of selected improvements in data collection and analysis procedures on pavement service life and discounted life-cycle pavement costs; and we shall compare the estimated reductions in life-cycle pavement costs to the required increases in data costs. The number of such analyses to be performed will be limited by the available staff time for performing these analyses (approximately 60 technical person-hours per state). However, we expect that the analyses to be performed will include the use of additional systems of grouping vehicle classes (e.g., using a pure length-based grouping). As in Task C, the analyses will presume the use of the AASHTO pavement-design procedure for PCC pavements. We will also implement and apply the corresponding procedure for AC pavements if the introduction of this analytic capability appears to be a cost-effective use of Task D resources.

### *Task E – Develop Guidelines*

The Statement of Work requests the development of guidelines that can be used by SHAs for performing the types of analyses performed in Tasks C and D. These analyses will enable SHAs to estimate the benefits and costs of adopting better procedures for estimating life-cycle ESALs. The guidelines will address the identification of variables to be used in the analyses, estimation of the means and variances of these variables, and analytic procedures to be used. All computer programs developed in Tasks C and D for performing these analyses will be provided to FHWA for distribution to SHAs, along with clear instructions for their use; however, no additional programs or program options will be developed as part of this task. The computer programs along with draft guidelines will be submitted to FHWA within one month of the completion of Task D.

### *Task F – Draft Final Report and Summary.*

In parallel with Task E, drafts of a Final Report and a Technical Summary will be prepared. The Draft Final Report will fully document the Task C analyses and the Task D case studies, and it will present the Task E guidelines, appropriately modified on the basis of any comments received from reviewers. The Task B literature review will be included in this report, most likely as an appendix.

The Draft Technical Summary will present: the study’s objectives; a summary of the findings of the Task C analyses and Task D case studies; and the major substance of the guidelines that appear in the Draft Final Report (exclusive of data formats and similar details).

The Draft Final Report and Technical Summary will be submitted within 15 days of the submission of the Task E Draft Guidelines to FHWA.

### *Task G – Final Report and Technical Summary*

Following receipt of reviewer comments, the Draft Final Report and Draft Technical Summary will be appropriately revised. Twenty bound copies each of the resulting Final Report and Technical Summary will be submitted to the COTR, along with one reproducible copy of each volume and electronic files in Word

Perfect format. A copy of the transmittal letter will also be furnished to the contracting officer.

### *Task H – Oral Presentations*

The Principal Investigator will make two oral presentations to the COTR describing study progress and providing the basis for discussions about our findings and recommendations. We suggest that the first of these meetings be held shortly after submission of the Task C Report to enable us to discuss in some detail the findings of the Task C analyses; and that the second be held either after completion of Task D or submission of the Task E Draft Guidelines.